

**ISOTHERMS AND KINETICS STUDIES  
OF LEAD ADSORPTION  
ON  
JATROPHA SEED HUSK**

**FAHEEM AHMED QAID MOHAMMED SGC080037**

**A RESEARCH PROJECT REPORT SUBMITTED IN FULFILMENT  
OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF  
SCIENCE  
ANALYTICAL CHEMISTRY AND INSTRUMENTAL ANALYSIS**

**DEPARTMENT OF CHEMISTRY  
FACULTY OF SCIENCE  
UNIVERSITY OF MALAYA  
KUALA LUMPUR  
NOV. 2010**

**SUPERVISOR  
DR. SHARIFAH BINTI MOHAMAD**

## **Abstract**

Presence of lead, a heavy metal in the environment has been a serious concern especially with rapid industrialization which has created new uses for lead. The acute toxicity of lead to aquatic Life and humans and the stringent effluent standard to be met by industries as specified by regulatory organizations has necessitated the development of innovative, effective and economical methods for treating lead-bearing wastewater. An adsorption process using an inexpensive adsorbent such as Jatropha seed husk is an attractive option for the removal of lead from wastewater.

In this study batch isotherm and kinetic studies were carried out on a laboratory scale to evaluate the adsorption capacity of Jatropha seed husk and contact time on lead removal was studied. Desorption studies were also conducted using deionized water to evaluate desorption of lead from Jatropha seed husk. Batch kinetic studies indicated that Jatropha seed husk was effective in removing 95.5% of lead. The equilibrium time was determined to be 60 min and pH was found to be  $5.5 \pm 2$ . The kinetics of adsorption of lead ions on Jatropha seed husk could be adequately described by the Lagergren model and pseudo-second order reaction rate model. The batch isotherm studies showed that the adsorption data can be described by the Langmuir and Freundlich. Langmuir model was found to describe the adsorption data better compared to the Freundlich.

## **Abstrak**

Kehadiran plumbum, logam berat dalam persekitaran telah menjadi perhatian serius terutamanya dengan industrialisasi yang pesat telah menjadikan penggunaan baru bagi plumbum. Ketoksikan akut menyebabkan hidupan air dan manusia dan standard efluen yang ketat yang harus dipenuhi oleh industri seperti yang ditetapkan oleh undang-undang organisasi telah menyebabkan keperluan pembangunan kaedah inovatif, efektif dan ekonomis untuk merawat air sisa plumbum. Proses jerapan menggunakan sekam biji *Jatropha* sebagai penyerap merupakan pilihan yang menarik untuk menyingkirkan plumbum dari air sisa.

Dalam kajian ini batch isotherm dan kajian kinetik dilakukan pada skala makmal untuk menilai keupayaan jerapan kulit biji *Jatropha* dan masa kenalan pada penysisihan plumbum dikaji. Kajian penyahjerapan juga dilakukan menggunakan air ternyahion untuk menilai nyahjerapan plumbum dari kulit biji *Jatropha*. Batch kajian kinetik menunjukkan bahawa sekam biji *Jatropha* sangat efektif dalam mengurangkan 95.5% plumbum dari akues. Masa keseimbangan tercapai pada 60 minit dan pada  $\text{pH } 5.5 \pm 2$ . Kinetik jerapan ion plumbum pada kulit biji *Jatropha* dapat dijelaskan oleh model Lagergren dan model kadar tindak balas pseudo-dua tingkat. Kajian batch isotherm menunjukkan bahawa data jerapan dapat dijelaskan oleh Langmuir dan Freundlich. Langmuir model dapat menggambarkan data jerapan lebih baik berbanding dengan Freundlich.

## **Acknowledgement.**

The success of this project can be attributed to the assistance from Allah by my supervisor Dr.Sharifah Mohamad who always give valuable advice guidance, suggestions, especially and also spent her time for me.

I wish to thank the Central Instrument Facility especially Fateh bin Nagliman for supporting the equipment to carry out this project.

I am especially grateful to all staffs of Faculty of Science and research students in laboratory for their assistance during my experiment.

My really thanks to all friends for their friendship, happiness, helpful and all enjoyable thing that never done throughout my study.

Most of all, I wish to express the sincere thanks to my father, my mother, my wife and everybody in my family for their infinite supporting, understanding and continuous inspiration.

## **CONTENTS**

ABSTRACT	I
ABSTRAK	I
ACKNOWLEDGEMENT	III
LIST OF FIGURES	VI
LIST OF TABLES	VII
LIST OF ABBREVIATION	VIII
<b>CHAPTER ONE</b>	
Introduction	1
Objective of This Project	3
<b>CHAPTER TWO</b>	
2.1 Theory of adsorption	4
2.1.1 Physisorption	4
2.1.2 Chemisorption	5
2.2 Factors that effect an adsorption	7
2.3 Impact of lead on aquatic ecosystems	8
2.4 Treatment methods for heavy metal removal	9
2.4.1 Modified Jatropha seed husk adsorption	10
2.4.2 Use of activated carbon for the removal of lead	11
2.4.3 Use of peat for the removal lead	13
2.5 Adsorption kinetics and equilibrium	16
2.5.1 Adsorption isotherms models	16
2.5.1.1 Langmir adsorption isotherm	17
2.5.1.2 Freundlich isotherm	19
2.6 Adsorption kinetic	20
2.6.1 Pseudo-first-order kinetic model	20
2.6.2 Pseduo-second-order-kinetic model	21

## **CHAPTER THREE:**

### **MATERIAL AND METHOD**

3.1 Preparation of glassware	22
3.2 Raw material and chemicals	22
3.3 Adsorbate	23
3.4 Modification of Jatropha seed husk	23
3.5 Preparation of lead solution	23
3.6 Calibration curve solutions	24
3.7 Effects of initial concentration and contact time	24
3.8 Equilibrium uptake experiment	25
3.9 Kinetic studies	25
3.10 Data analysis	26

## **CHAPTER FOUR:**

### **RESULTS AND DISCUSSION**

(4.1) Effect of agitation time and initial Pb(II) concentration on modified Jatropha seed husk	27
4.2 Adsorption isotherms	29
4.2.1 Langmuir isotherm model	29
4.2.2 Freundlich isotherm	32
4.3 Adsorption kinetics	33

## **CHAPTER FIVE**

CONCLUSIONS	36
REFERENCES	38

## LIST OF FIGURES

Figure.2.1: Mechanism of adsorption process	6
Figure.2.2: Schematic representation of adsorbate-adsorbent-solvent relationship	7
Figure 2.3: Various curves that can be used to determine the shape of an isotherm from Information in Table 2.1.	19
Figure 4.1: Adsorption kinetics of lead on jatropha seed husk at different Initial lead concentration. Conditions: 250 $\mu\text{m}$ particle size, 0.1 g/L dose, 298 K temperature and pH 5.5 $\pm$ 2.	28
Figure 4.2 : Langmuir adsorption isotherm for Pb(II) adsorption on Jatropha seed husk at pH 5.5 $\pm$ 2; Dosage(0.1 g).	30
Figure 4.3: The calculated separation factor (RL) against Pb(II) ions concentrations (mg/L)	31
Figure 4.4: Linearized Freundlich isotherms for the adsorption of lead on Jatropha seed husk modified by Jatropha seed husk at room temperature.	33
Figure 4.5: Pseudo-first order kinetics for the adsorption of lead on Jatropha seed husk modified by H <sub>2</sub> SO <sub>4</sub> at different initial concentrations and room temperature.	35
Figure 4.7: Pseudo-second order kinetics for the adsorption of lead on Jatropha seed husk modified by H <sub>2</sub> SO <sub>4</sub> at different initial concentrations and room temperature.	35

## LIST OF TABLES

Table 2.1: Removal of anions, heavy metals, organics and dyes using jatropa seed husk carbon in comparison with coir pith carbon in the presence (ZnCPC) and absence (CPC) of ZnCl <sub>2</sub> activation.	10
Table 2.1: Use of separation factor $R_L$ in obtaining information about the nature of adsorption (Hall et al., 1966).	18
Table 4.1: Langmuir parameter $R_L$ for the adsorption of lead on jatropa seed husk.	31
Table 4.2: Adsorption isotherm constants for the adsorption of lead(II) ions onto Jatropha seed husk.	32
Table 4.8: Pseudo-first and pseudo second order adsorption rate constants, the calculated and experimental $q_e$ values for the adsorption of lead onto Jatropha seed husk modified by H <sub>2</sub> SO <sub>4</sub> at different initial concentrations and room temperature.	34



## LIST OF ABBREVIATION

$q_e$	amount of metal ion adsorbed at equilibrium.
$q_m$	maximum adsorption capacity
$b$	amount of adsorbate adsorbed per unit weight of adsorbent (mg/g)
$C_e$	concentration of adsorbate in solution at equilibrium (mg/L).
mg	milligram
L	liter
g	gram
$q_{max}$	the maximum adsorption capacity corresponding to complete monolayer coverage on the surface (mg/g)
$R_L$	separation factor
$n$	adsorption equilibrium constant
$K_F$	Freundlich constants
$K_L$	Lagergren rate constant for adsorption ( $h^{-1}$ ).
h	hour
$q_t$	amount of metal ion adsorbed at any time
$K_2$	the second order reaction rate constant for adsorption
$R^2$	correction coefficient
$C_o$	initial metal concentrations in the solution
$C_e$	concentration of adsorbate in solution at equilibrium
V	throughput volume
W	dry weight (g) of the added Modification jatropha seed husk
$a_t$	amount of $Pb^{2+}$ adsorbed from lead solution by the adsorbent at the various time
%Rem	percentage of Lead metal removed from the aqueous solutions by the adsorbent.
rpm	revolutions per minute
T	absolute temperature
t	time
min	minute
$C_i$	initial metal concentration (in equation 4.1)
K	Kelvin (in figure 4.1)
$M_1$	high or original concentration
$V_1$	volume needed of original concentration

$M_2$  low or new concentration

$V_2$  total volume of new concentration